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Report: The carbon impacts of straw logs for domestic solid fuel burners

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The carbon impacts of straw logs for domestic solid fuel burners

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The following summarises the energy and carbon implications of using straw waste from agricultural cereal production, compressed into logs, for use in domestic wood or multi-fuel burners.

Coal, gas and other fossil fuels contain carbon which was once extracted from the atmosphere by living matter. The burning of fossil fuels is therefore carbon neutral to the atmosphere over the timescales that these fossil fuels are created (tens to hundreds of millions of years). The current debate about man's effect on the climate is the climate forcing which takes place due to the introduction of extra carbon dioxide over the timescale of tens of years, with the effects by 2050 being a common time horizon [1]. Over this timescale, straw is carbon neutral (ignoring the energy implications of processing) but wood is not because the regrowth of a tree is longer than the 40 years to 2050. Using straw negates the problems associated with timescale. A tree cut down and burned in 2010 leads to higher levels of carbon dioxide in the atmosphere in 2050 than if that energy was provided by straw because of the length of the tree growth cycle.

As with many other biofuels, the true carbon impact is greater than that implied by a simple carbon cycle view where carbon dioxide is absorbed whilst the biomass is growing and released when burned. There are intermediate steps in the growing, harvesting and processing which are energy and carbon intensive. This has caused significant controversy, most notably in the US for corn-based ethanol. It is these indirect emissions which are studied and quantified in this report.

The life-cycle emissions of straw logs will include growing the straw, farm processing, transport to the log making facility, log making and transport to market. Finally, the total carbon intensity of the straw logs are compared with other commercial fuels.

Information on the crop growth comes from CLAAS UK [2]. Data on straw bale collecting, and all processes up to processing and distribution come from David Thompson [3]. Greenhouse gas conversion factors come from the DEFRA 2007 Guidelines [4]. The energy density of wood/straw comes from the Biomass Energy Foundation [5].

Growing of the crop

Straw is a by-product of agricultural cereal production and its carbon intensity is essentially zero as it will release as much carbon dioxide into the atmosphere whether burned or ploughed back into the soil (due to the action of microorganisms) as has been absorbed during its growth. However, there are a number of examples where this equal input/output ratio can be altered:

Issues where removing straw may increase carbon emissions
additional potash fertiliser - removal of the straw reduces the nutrients available to the next crop
soil compaction – due to reduced biomass in the soil, though this can be mediated by good techniques

Issues where removing straw may decrease carbon emissions
ground tillage – it requires energy and therefore carbon to incorporate the straw into seeds beds using popular minimum tillage methods
slugs – slugs thrive on the chopped straw and slug pellets have to be produced and applied
next crop establishment – can be delayed by the presence of straw
NO2 or methane (from rotting straw) – this is significant though difficult to quantify

The examples listed above are not easily quantified and it is considered reasonable to assume that straw has zero carbon intensity for the growth stage - straw is a waste product that its removal has competing carbon implications but only the implications beyond growth will now be considered.

Combining

Where the straw is not to be removed but is to be ploughed back into the soil, then it requires combining and chopping. This takes 2 litres of diesel per tonne of straw. Combining and laying for baling requires only 1.25 litres of diesel per tonne of straw because the choppers are switched off.

CO2 impact – 1.25*2.63 = 3.29 kgCO2/tonne straw

Baling

Baling requires 0.5 litres of diesel per tonne straw.

CO2 impact – 0.5*2.63 = 1.315 kgCO2/tonne straw

Straw collecting and transport

Bales are collected from the farm at 0.5 litres of diesel per tonne of straw. Transport is always within 30 km and this requires a further 1.5 litres of diesel per tonne of straw.

CO2 impact – (0.5+1.5)*2.63 = 5.26 kgCO2/tonne straw

Straw drying

The straw is dried to reduce the water content from 15% to below 10% using the nearly 1MW wasted heat from the facility generator. This waste heat is considered to be zero carbon. The drying process reduces the weight of straw by about 6%.

Log forming

Log forming from the dried straw uses 100 kWh per tonne of logs for the extruder, saw, conveyor and extraction fan. There is a further 100 kWh per tonne of logs for chopping, conveyors and fans. The weight loss from straw to log will be small (some further water loss and a little pyrolysis of the outer straw layer).

CO2 impact – 200*0.523 = 104.6 kgCO2/tonne straw

Log distribution

Assuming the straw logs will be delivered within 30 km (the same area over which the straw was harvested), delivery then takes 1.5 litres of diesel per tonne of delivered logs.

CO2 impact – 1.5*2.63 = 3.94 kgCO2/tonne straw

Other emissions associated with business

There are no other power sources associated with the business apart from the generator.

Summary

The carbon impact of 1 tonne of straw logs is dominated by the energy required in log forming. Further investigation would further investigate this energy use as it is an estimate.

CO2 impact up to drying – 3.29+1.315+5.26 = 9.87 kgCO2/tonne straw from the field
CO2 impact after drying – 9.87/0.94 = 10.5 kgCO2/tonne dry straw

CO2 impact of log forming = 104.6 kgCO2/tonne straw logs

CO2 impact of log distribution = 3.94 kgCO2/tonne straw logs

<u>Total CO2 impact of straw logs = 119 kgCO2/tonne straw logs</u>

Assuming the energy density of straw logs is similar to that of dry wood (18 MJ/kg), this gives the CO2 impact of straw logs as...

<u>Total CO2 impact of straw logs = 0.119/18 = 0.007 kgCO2/MJ</u>

and as there are 3.6 MJ per kWh

<u>Total CO2 impact of straw logs = 3.6*0.119/18 = 0.024 kgCO2/kWh</u>

This compares to 0.258 kgCO2/kWh for burning oil
and 0.206 kgCO2/kWh for natural gas

The carbon impact of straw logs is therefore just under 10% of that from burning oil and just over 10% that of natural gas. The major improvements to these calculations would be the net carbon implication of removing straw from the land rather than ploughing it back in and the energy for log forming (which are estimates which could be improved). Offset emissions of greenhouse gases from rotting straw in the field would also need to be considered.

References

1 – UK Energy Research Centre – Energy 2050 Project - http://www.ukerc.ac.uk/support/tiki-index.php?page=Energy+2050+Overview

2 – CLAAS, UK - http://www.claas.co.uk/group/generator/cl-gr/en/home,lang=en_UK.html

3 – David Thompson, Agripellets Ltd - http://www.agripellets.com/

4 – DEFRA conversion factors - http://www.defra.gov.uk/environment/business/reporting/pdf/conversion-factors.pdf

5 – The Biomass Energy Foundation - http://www.woodgas.com/fuel_densities.htm